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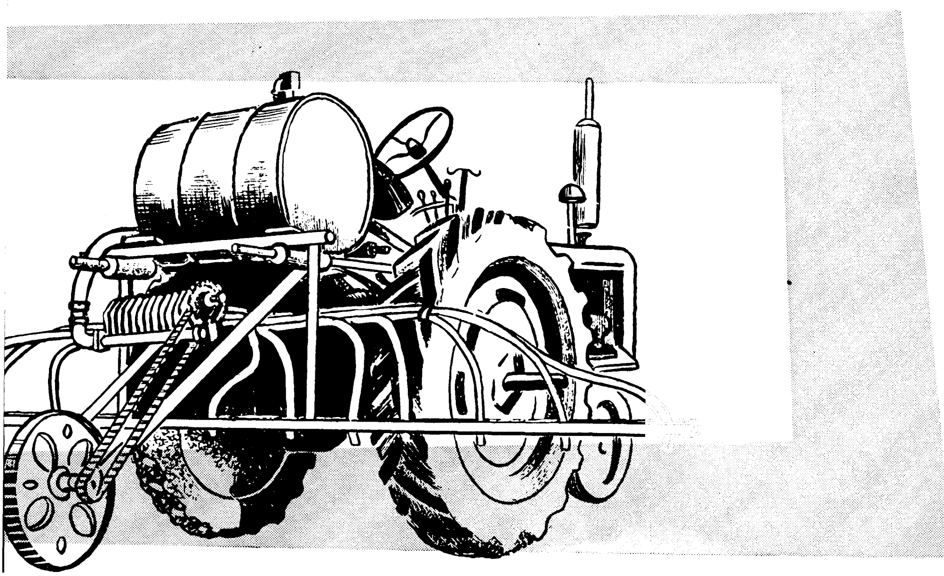
hose pump

for applying fertilizer solutions



• OPERATION • ADVANTAGES
• REGULATING THE PUMP

FARMERS BULLETIN NO. 2128
U. S. DEPARTMENT OF AGRICULTURE

This publication was prepared by Charles W. Gantt, Jr., and Walter C. Hulburt of the Agricultural Engineering Research Division, Agricultural Research Service, USDA, and Henry D. Bowen of the Agricultural Engineering Department, North Carolina State College.

The hose pump was originally designed and patented by the University of Tennessee in cooperation with the Tennessee Valley Authority. It was modified to improve performance and field tested by the authors. Dale B. Eldredge assisted in construction developments at the Agricultural Engineering Research Laboratory, Beltsville, Md. The Liberty Manufacturing Co., Red Springs, N. C., assisted in field studies.

This bulletin supersedes Farmers' Bulletin 2096, Hose Pump for Applying Nitrogen Solutions.

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hose pump

for applying fertilizer solutions

Fertilizers in liquid form are easier to handle and often cost less per unit than in the dry form. Until recently, however, only large farm operators have found it economical to purchase and use their own liquid application equipment.

Development of a hose pump that uniformly measures fertilizer solutions or nitrogen solutions[1] makes it possible for more farm operators to own and operate their own equipment and thus take advantage of the saving in cost between liquid and dry fertilizers.

The pump is manufactured in models costing $100 to $200. It weighs about 25 pounds, and can be mounted easily on a tractor or on a tractor-drawn implement. It can be used for making surface or subsurface applications of fertilizer solutions before or at the time of planting, for applying the solutions as side-dressing or top-dressing, and for applying them to crop residues that are to be plowed under.

Studies during the early 1950's in North Carolina indicate that a farmer is justified in investing $100 in nitrogen-solution equipment if he is going to use it each year on 12 acres or more, and $200 if he is going to use it on 22 acres or more.

OPERATION

The pump consists of 1 to 12 or more flexible, plastic-type hoses that are stretched over a 4-roller reel. It is connected to a supply tank by a feed line. The tank must be open or vented during field operation. To assure uniform application, mount the pump so that it is 1 foot or more below the bottom of the tank.

As the reel turns, the rollers move along the hoses. The hoses close when a roller comes in contact with them; they open again after the roller passes. The contact of the rollers with the hoses as the reel turns creates a pumping action that pulls and pushes the solution forward and discharges it at the open ends of the hoses.

When ready to operate, the hoses are stretched over the rollers tightly enough to prevent flow of the fertilizer solution through the hoses unless the reel is turning. When not operating for long periods, the hoses should be loosened to prolong their useful life.

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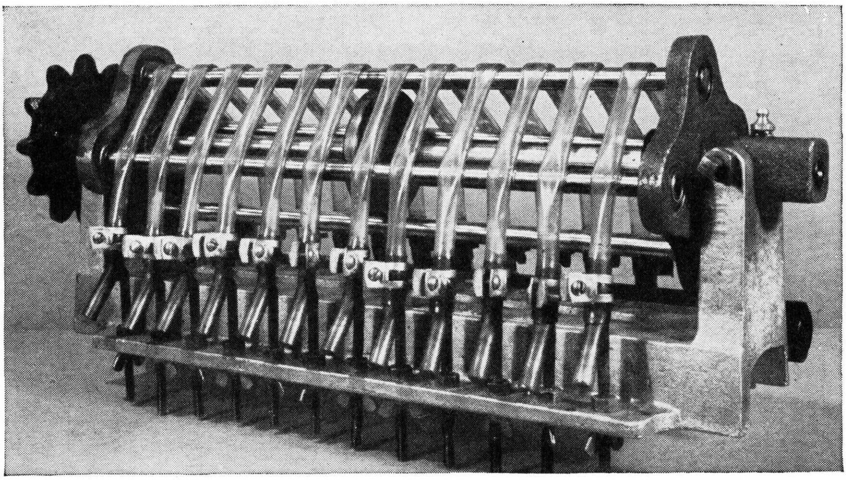
[1] Fertilizer solutions are combinations of two or more of the major plant nutrients in liquid form. Nitrogen solutions are nitrogen fertilizers in solution at low pressure. This hose pump is not used to meter high-pressure nitrogen fertilizer (such as anhydrous ammonia).



F 2850

Output side of 12-hose pump showing hoses stretched over the reel rollers.

For surface application, the hoses can be tied to a homemade boom. For subsurface application, the hoses can be tied back of cultivator shovels, plows, or various types of fertilizer applicator shanks.

FEATURES

1. One hose pump unit operates as 1 to 12 or more single pumps (depending on the number of hoses) but it costs no more than single pumps of some types.

2. The pump can be driven from a ground wheel because it meters the solution accurately at reel speeds of 50 to 400 revolutions per minute. This makes it possible to apply net plant nutrients at approximately 20 to 200 pounds per acre. The range of application rates depends on concentration of plant nutrients in the solution, width of area served by each hose of the pump, as well as speed of revolution of the hose reel.

3. The rate of fertilizer application is constant, at a given setting, regardless of ground speed. This means that all plants get an equal share of the fertilizer regardless of tractor speed.

4. No cutoff valve is required because the flow stops when the reel stops turning.

5. No corrosion of moving parts of the pump can occur because the solutions do not come in contact with these parts of the pump.

6. The pump requires no return by-pass line.

7. No orifices are required in the distribution lines to insure equal distribution to a series of outlets, as required in a pump having a manifold distribution system, because each hose is a separate metering pump.

8. The reel is not damaged if the pump is operated dry after the solutions run out. (The hoses may be injured somewhat or lose their resiliency if operated dry more than a few minutes.)

9. The desired rate of application can be obtained without trial-and-error runs.

10. The cost of repair and replacement of parts is low. Most farmers will probably find that a set of hoses will last 2 or 3 years. Replacement of a set of 12 hoses over the reel costs about $5.

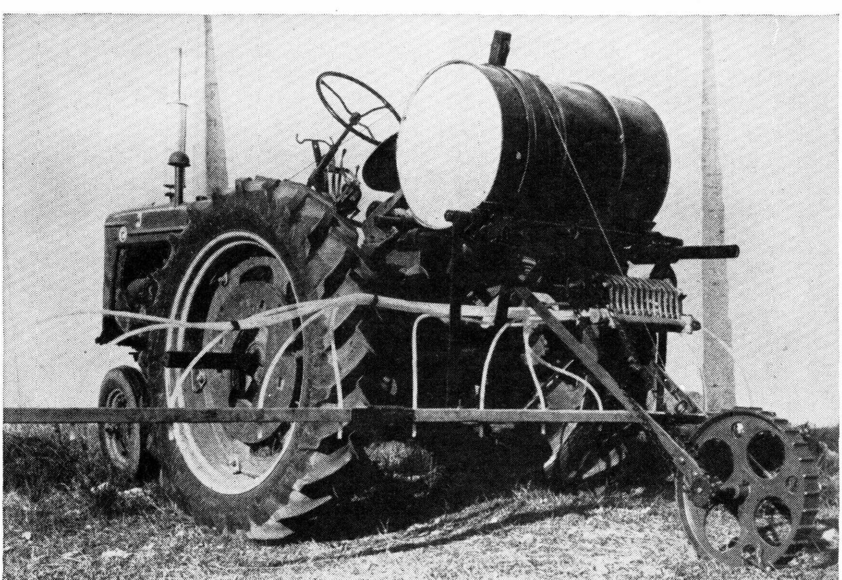
REGULATING THE PUMP

The rate at which the reel turns governs the amount of the fertilizer discharged by each hose on the pump. One of the important characteristics of this pump is that there is a direct ratio of the speed of the reel to the amount of discharge of the hoses. In other words, increasing reel speed from 100 to 200 r. p. m. doubles the amount of fertilizer discharged.

The reel is turned by the ground wheel of the equipment on which the pump is mounted, or some equivalent drive. Sprockets on the reel and the ground wheel are connected by a suitable chain drive or other mechanical means of power transmission. The rate at which the reel turns is therefore in direct ratio to the rate at which the ground wheel turns. By varying the ratio you can change the rate at which fertilizer is applied to the soil.

To vary the ratio, change the size of sprockets. This will increase or decrease the number of times the reel turns with each turn of the ground wheel, thereby increasing or decreasing the amount of fertilizer that is discharged through each hose on the pump.

The method you use to determine the size of the sprockets depends on whether the chain drive has 2 sprockets, or 4 sprockets (as when using a counter shaft). A 4-sprocket drive (illustrated on p. 8)



Typical hose pump installation on tractor showing supply tank, pump, hoses tied to boom, and ground wheel. (Courtesy of The Liberty Manufacturing Company)

permits a more exacting rate of application and a much wider range of rates than a 2-sprocket drive (illustrated on the cover).

Two-Sprocket Chain Drive

If you use a 2-sprocket chain drive, an easy way to vary the ratio between the reel turns and the ground wheel turns is to change the size of the sprocket on the reel. To determine the reel-sprocket size needed for a particular job (1) decide on the per-acre rate at which you want to apply fertilizer, (2) take certain measurements, and (3) make a few simple calculations.

Application rate

Refer to the table on p. 12 for information to assist in calibration of the metering hose pumps or other application equipment of fertilizer solutions. From this table can be determined the gallonage per acre which is equivalent to the pound per acre rates of dry fertilizers.

Example:

Suppose you have previously applied 400 pounds per acre of a 5–10–5 dry fertilizer to a given field, and now want to apply liquid fertilizer at a rate to obtain the same net plant food. Refer to the left column that lists "weight of dry fertilizer of similar analysis per acre." Note the line showing 400 pounds. Follow this line to the right, and under the 5–10–5 column you will note that the equivalent rate is 40 gallons. This figure is based on the estimate that a gallon of liquid fertilizer weighs 10 pounds. For more precise calculations, refer to the weight shown on the manufacturer's label and make any necessary adjustments.

Another example shows how to convert a rate of 700 pounds of a 10–10–10 dry fertilizer per acre to the equivalent in liquid fertilizer. Since it is quite probable that you cannot purchase a 10–10–10 mixed fertilizer solution, it is necessary to change the percentage rate of 10–10–10 to pounds per acre of the 3 primary plant food elements. In other words, 700 pounds of 10–10–10 means 70 pounds of nitrogen, 70 pounds of phosphate, and 70 pounds of potassium. This is a 1–1–1 ratio. Note that an 8–8–8 fertilizer is also a 1–1–1 ratio. Under the 8–8–8 column, find the line showing 64–64–64 net pounds opposite 80 gallons per acre, and 72–72–72 opposite 90 gallons per acre. It would appear, therefore, that a rate of 87 or 88 gallons of liquid fertilizer per acre would closely approximate the desired application rate. Similar examples may be worked out for the application of nitrogen fertilizer.

Use the table on page 12 to convert pounds of plant nutrients or net nitrogen to gallons of fertilizer solution.

Example:

If you want to apply *nitrogen* at the rate of 40 pounds (net weight) per acre, the table indicates that you will need to

apply the following amounts of nitrogen solution per acre: 17.8 gallons of 21-percent nitrogen, 11.3 gallons of 32-percent nitrogen, 10.9 gallons of 37-percent nitrogen, or 10.3 gallons of 41-percent nitrogen.

Measurements

Following are the measurements needed, and how to take the measurements.

1. The number of times the reel turns to discharge 1 gallon of fertilizer through 1 hose.

Half fill the tank with fertilizer solution. Operate the pump enough to discharge 1 pint into a container that is held under 1 hose. Count the number of reel turns required to fill the container and multiply by 8, the number of pints in a gallon.

2. The width of the field strip to be treated by 1 hose.

Measure the width of a row in the field. Use this measurement in your calculations if 1 hose is to treat 1 row. If 1 hose is to treat 2 rows, multiply the row width by 2; if 2 hoses are to treat 1 row, divide the row width by 2. If the hoses are tied to an applicator boom, use the measured distance between hoses.

3. The circumference of the ground wheel.

Measure the distance the equipment travels under field operating conditions in 10 turns of the ground wheel. Divide the distance by 10. An alternate method is to measure the distance from the center of the axle to the ground surface and multiply the distance by 6.28. If you use this method, allow for wheel slippage that will occur under field conditions. Subtract a 5- to 10-percent estimate for wheel slippage if the ground wheel is power driven (like a tractor wheel), but add the slippage estimate if the ground wheel is not power driven, but is rolling freely.

Calculations

First step.—Multiply the number of gallons of fertilizer solution per acre by the number of reel turns per gallon by the width of the strip (in feet) by the ground wheel circumference (in feet) and divide the product by 43,560.

The calculation will give the ratio between the rate at which the reel turns and the rate at which the ground wheel turns.

Example:

(1) Your application rate is 40 pounds (net weight) per acre of 41-percent nitrogen solution. The table shows that this rate requires an application of 10.3 gallons per acre.

(2) The reel turns 50 times to discharge 1 pint from 1 hose. Fifty multiplied by 8 is 400—the number of reel turns to discharge 1 gallon.

(3) Each hose is to treat 1 row. The row is 42 inches, or 3.5 feet, wide.

(4) The equipment travels 125 feet in 10 wheel turns. The distance divided by 10 is 12.5 feet.

$$\text{Ratio} = \frac{10.3 \times 400 \times 3.5 \times 12.5}{43,560}$$

$10.3 \times 400 = 4120$
$3.5 \times 12.5 = 43.75$
$4120 \times 43.75 = 180,250$
$180,250 \div 43,560 = 4.14$

The computed ratio is 4.14, which means that the reel turns a little more than 4 times with each turn of the ground wheel.

Second step.—Divide the size of the sprocket on the ground wheel by the computed ratio. This will give the sprocket size for the reel.

Examples:

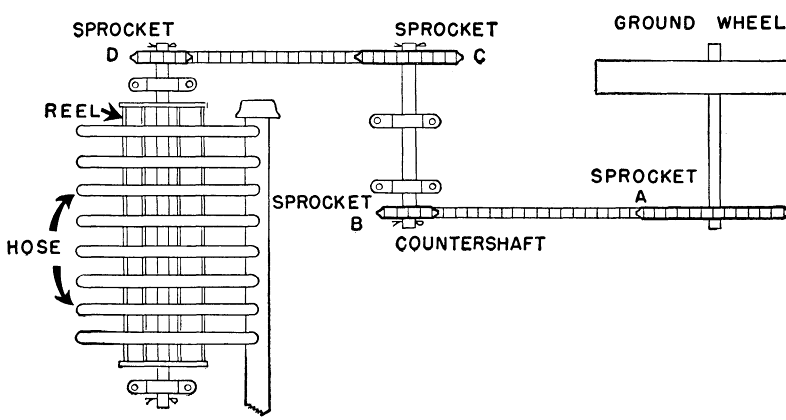
(1) The ground wheel has a 24-tooth sprocket. The computed ratio is 4.14. Twenty-four divided by 4.14 is 5.8. Therefore, use a 6-tooth sprocket (the nearest size) on the reel.

(2) The ground wheel has a 32-tooth sprocket. The computed ratio is 4.14. Thirty-two divided by 4.14 is 7.7. Therefore, use an 8-tooth sprocket (the nearest size) on the reel.

Four-Sprocket Chain Drive

If you use a 4-sprocket chain drive similar to the one shown in the accompanying drawing, vary the ratio between the reel turns and the ground wheel turns by changing the size of sprockets B, C, and D. Leave sprocket A, the drive sprocket on the ground wheel, in place.

Determine the size of sprockets B, C, and D in the same way that you determine the size of the reel sprocket in a 2-sprocket chain drive, but add one item to the first step of the calculations (size of sprocket on drive wheel—note example below).



Calculations

First step.—Multiply the number of gallons of fertilizer solution per acre by the number of reel turns per gallon by the width of the strip (in feet) by the ground wheel circumference (in feet) and divide the product by the number of teeth of the drive sprocket on the ground wheel multiplied by 43,560.

Example:

(1) The application rate and the measurements are the same as those in the first example on page 6.

(2) The ground wheel has a 24-tooth sprocket (sprocket A).

$$\text{Ratio} = \frac{10.3 \times 400 \times 3.5 \times 12.5}{24 \times 43{,}560}$$

$10.3 \times 400 = 4120$
$3.5 \times 12.5 = 43.75$
$4120 \times 43.75 = 180{,}250$
$24 \times 43{,}560 = 1{,}045{,}440$
$180{,}250 \div 1{,}045{,}440 = .1725$

The computed ratio (or, in this example, sprocket factor) of reel turns to ground wheel turns is .1725.

Second step.—Use the table on pages 10 and 11 to determine the size of sprockets B, C, and D. The table gives the size of sprockets to use with various computed ratios ranging from .0417 to .6667.

Example:

The computed ratio is .1725.

The ratio given in the table that is nearest to the computed ratio is .1728 (the first figure at the top of the page in the second column from the right). The other numbers on the same line are the size of sprockets to use. B should be a 9-tooth sprocket, C a 14-tooth sprocket, and D a 9-tooth sprocket.

Third step.—Place the sprockets listed in the table (opposite the calculated ratio) on their respective places in the drive train. Run a trial test to check the correctness of the calibration of the pump.

Example:

Place a 9-tooth sprocket on the driven sprocket position on the countershaft; a 14-tooth sprocket on the driver sprocket position; and a 9-tooth sprocket on the pump shaft. Run a trial test of about 1/10 or 1/100 acre to determine if a little over 8 pints or 3/4 pint is discharged, which will indicate an application rate of 10.3 gallons of solution per acre.

Other Considerations

You can also change the rate at which fertilizer solutions are applied by changing the number of hoses used, or by changing to hoses that have smaller or larger diameters. (The calculations for determining sprocket sizes, and the tables on pages 10, 11, and 12, will apply regardless of the size of the hoses used.) You can decrease the rate at which fertilizer is applied by diluting the solution with water.

Since the pump should be used with an open tank, you may want to add water to the low pressure nitrogen solutions, especially in hot weather, to avoid loss of free ammonia. The addition of water in cold weather will lower the salting-out temperature—the point at which nutrients crystalize.

Relationship of computed ratio (R) to size of sprockets B, C, and D

R	B	C	D	R	B	C	D	R	B	C	D	R	B	C	D	R	B	C	D	R	B	C	D
.0417	12	8	16	.0673	8	7	13	.0972	9	14	16	.1327	7	13	14	.1728	9	14	9	.2333	6	14	10
.0420	11	6	13		13	14	16		12	14	12	.1333	6	8	10	.1746	7	11	9	.2344	8	15	8
.0424	11	7	15	.0682	11	9	12	.0982	8	11	14		10	16	12	.1750	8	14	10	.2381	7	15	9
.0429	14	6	10		11	12	16	.0992	11	12	11	.1346	8	14	13	.1758	7	16	13	.2400	10	24	10
	14	9	15	.0688	10	11	16	.1000	8	12	15	.1354	8	13	12	.1778	9	16	10	.2407	6	13	9
.0433	13	9	16	.0694	12	10	12		10	8	8	.1358	9	11	9	.1786	7	10	8	.2424	9	24	11
.0438	10	7	16	.0700	10	7	10	.1016	8	13	16	.1364	8	12	11	.1795	6	14	13	.2449	7	12	7
.0440	13	8	14	.0707	9	7	11	.1026	12	16	13	.1368	9	16	13	.1806	6	13	12	.2500	7	14	8
.0446	14	10	16	.0710	13	12	13	.1037	9	14	15	.1375	8	11	10	.1818	8	16	11		8	16	8
.0449	12	7	13	.0718	13	14	15	.1042	8	10	12	.1389	6	10	12	.1833	6	11	10	.2540	7	16	9
.0455	11	7	14	.0721	13	15	16	.1058	8	11	13	.1400	10	14	10	.1837	7	9	7	.2593	6	14	9
	11	8	16	.0729	8	7	12	.1067	10	16	15	.1414	9	14	11	.1846	10	24	13	.2619	6	11	7
.0458	10	11	24		16	14	12	.1071	8	12	14	.1420	13	24	13	.1852	9	10	6	.2637	7	24	13
	15	11	16	.0733	10	11	15	.1074	11	13	11	.1429	7	8	8		9	15	9	.2653	7	13	7
.0462	13	9	15	.0741	9	8	12	.1083	8	13	15		8	16	14	.1857	7	13	10	.2667	9	24	10
.0467	10	7	15	.0750	10	12	16		10	13	12	.1442	8	15	13	.1875	6	9	8	.2679	8	15	7
.0469	16	9	12	.0764	9	11	16	.1094	8	14	16	.1444	9	13	10		8	12	8	.2708	6	13	8
	16	12	16	.0774	12	13	14	.1100	10	11	10	.1455	10	16	11	.1905	6	8	7	.2727	8	24	11
.0473	13	8	13	.0778	9	7	10	.1111	9	8	8	.1458	12	14	8		6	16	14	.2778	6	15	9
.0476	12	8	14		12	14	15		12	16	12	.1477	8	13	11	.1923	6	15	13	.2857	7	14	7
.0481	13	10	16	.0788	11	13	15	.1122	7	11	14	.1481	9	16	12	.1944	6	14	12		7	16	8
.0485	11	8	15	.0795	8	7	11	.1125	8	9	10	.1500	8	12	10	.1948	7	15	11	.2917	6	14	8
.0486	9	7	16		11	14	16	.1136	8	10	11	.1515	9	15	11	.1964	7	11	8	.2963	9	24	9
	12	7	12		16	14	11	.1143	10	16	14		11	10	6	.1970	6	13	11	.3000	8	24	10
.0491	14	11	16	.0800	10	8	10	.1154	13	12	8	.1524	7	16	15	.1975	9	16	9	.3056	6	11	6
.0495	13	9	14	.0813	10	13	16	.1167	10	14	12	.1528	8	11	9	.1983	11	24	11	.3061	7	15	7

.0500	10	8	16	.0818	10	9	11	.1172	8	15	16	.1531	7	15	14	.2000	6	12	10	.3077	6	24	13
.0510	14	10	14	.0833	6	8	16	.1182	10	13	11	.1538	8	16	13		8	16	10	.3095	6	13	7
.0521	12	10	16		8	10	15	.1190	7	10	12	.1548	6	13	14	.2031	8	13	8	.3117	7	24	11
.0530	11	7	12	.0844	11	13	14		14	10	6	.1556	9	14	10	.2041	7	10	7	.3125	6	15	8
.0536	14	12	16	.0855	9	10	13	.1200	10	12	10	.1563	8	10	8	.2051	6	16	13	.3265	7	16	7
.0545	11	9	15	.0864	9	7	9	.1209	7	11	13	.1571	7	11	10	.2063	7	13	9	.3333	6	14	7
.0556	12	8	12	.0867	10	13	15	.1212	6	8	11	.1587	7	10	9	.2078	7	16	11		6	16	8
.0563	10	9	16	.0875	10	14	16		9	12	11	.1591	8	14	11	.2083	8	15	9	.3429	7	24	10
.0571	10	8	14	.0888	13	15	13	.1224	7	12	14	.1600	10	16	10	.2121	6	14	11	.3571	6	15	7
.0583	15	14	16	.0889	9	8	10	.1235	9	10	9	.1607	7	9	8	.2143	7	12	8	.3611	6	13	6
.0595	14	10	12	.0893	8	10	14	.1250	6	12	16	.1616	9	16	11	.2167	6	13	10	.3636	6	24	11
.0600	10	6	10	.0900	10	9	10		8	10	10	.1625	8	13	10	.2182	10	24	11	.3750	8	24	8
	10	9	15	.0909	11	8	8	.1270	7	8	9	.1633	7	8	7	.2188	8	14	8	.3810	6	16	7
.0612	14	12	14	.0917	10	11	12	.1273	10	14	11		7	16	14	.2222	6	8	6	.3889	6	14	6
.0615	10	8	13	.0926	9	10	12	.1282	6	10	13	.1648	7	15	13		6	16	12	.4000	6	24	10
.0625	12	6	8	.0933	10	14	15	.1286	7	9	10	.1667	6	8	8		9	16	8	.4167	6	15	6
	16	8	8	.0938	8	12	16	.1296	9	14	12		8	16	12	.2245	7	11	7	.4286	7	24	8
.0635	9	8	14	.0947	13	16	13	.1299	7	10	11	.1678	11	24	13	.2273	6	15	11	.4444	6	16	6
.0641	12	10	13	.0952	6	8	14	.1300	10	13	10	.1688	7	13	11	.2286	7	16	10	.4898	7	24	7
.0649	11	10	14		12	16	14	.1313	9	13	11	.1705	8	15	11	.2292	6	11	8	.5000	6	24	8
.0655	12	11	14	.0963	9	13	15	.1319	7	12	13	.1714	7	12	10	.2308	8	24	13	.5714	6	24	7
.0667	10	8	12	.0972	6	7	12	.1322	11	16	11	.1719	8	11	8	.2321	7	13	8	.6667	6	24	6

Rates of application of plant nutrients per acre converted to gallons

Weight of dry fertilizer of similar analysis per acre (pounds)	Mixed fertilizer solutions: Equivalent gallons [1] and net application of plant nutrients: 8-8-8				5-10-5				5-10-10				Nitrogen fertilizer solutions: Actual nitrogen per acre	Corresponding number of gallons of different nitrogen solutions: 21% N	32% N	37% N	41% N
	Gal.	*Net lb.*			*Gal.*	*Net lb.*			*Gal.*	*Net lb.*			*Lb.*	*Gal.*	*Gal.*	*Gal.*	*Gal.*
50	5	4	4	4	5	2½	5	2½	5	2½	5	5	20	8.9	5.6	5.5	5.1
100	10	8	8	8	10	5	10	5	10	5	10	10	25	11.1	7.1	6.8	6.4
150	15	12	12	12	15	7½	15	7½	15	7½	18	15	30	13.3	8.5	8.2	7.7
200	20	16	16	16	20	10	20	10	20	10	20	20	35	15.6	9.9	9.5	9.0
250	25	20	20	20	25	12½	25	12½	25	12½	25	25	40	17.8	11.3	10.9	10.3
300	30	24	24	24	30	15	30	15	30	15	30	30	45	20.0	12.7	12.3	11.5
350	35	28	28	28	35	17½	35	17½	35	17½	35	35	50	22.2	14.1	13.6	12.8
400	40	32	32	32	40	20	40	20	40	20	40	40	55	24.4	15.5	15.0	14.1
450	45	36	36	36	45	22½	45	22½	45	22½	45	45	60	26.7	16.5	16.4	15.4
500	50	40	40	40	50	25	50	25	50	25	50	50	65	28.9	18.4	17.7	16.7
600	60	48	48	48	60	30	60	30	60	30	60	60	70	31.1	19.8	19.1	17.9
700	70	56	56	56	70	35	70	35	70	35	70	70	75	33.3	21.2	20.4	19.2
800	80	64	64	64	80	40	80	40	80	40	80	80	80	35.6	22.6	21.8	20.5
900	90	72	72	72	90	45	90	45	90	45	90	90	90	40.0	25.4	24.5	23.1
1,000	100	80	80	80	100	50	100	50	100	50	100	100	100	44.4	28.2	27.3	25.6
													120	53.3	33.9	32.7	30.8
													130	57.8	36.7	35.4	33.3
													140	62.2	39.6	38.2	35.9
													150	66.7	42.4	40.9	38.5
													200	88.9	56.5	54.5	51.3

[1] Fertilizer solutions weigh from 9.7 to 10.3 pounds per gallon. For general usage, a value of 10 pounds per gallon is sufficiently accurate.